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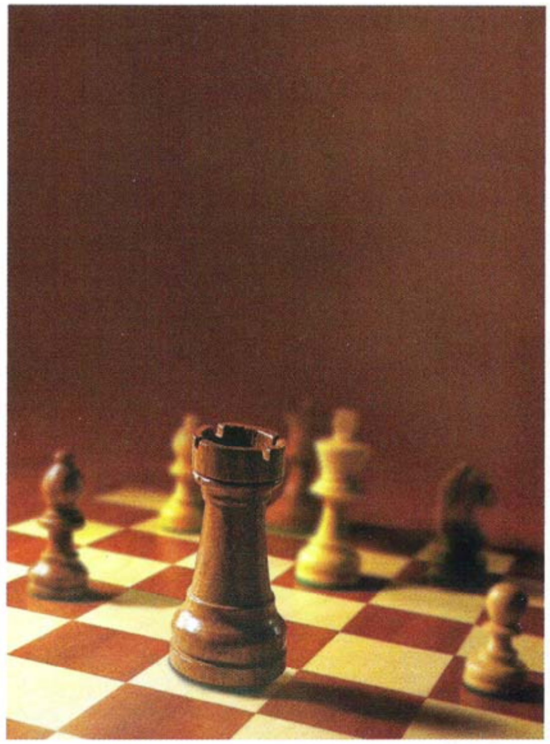

onthe**cover**
SERVICE CENTERS
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Temperature controls improve coating quality

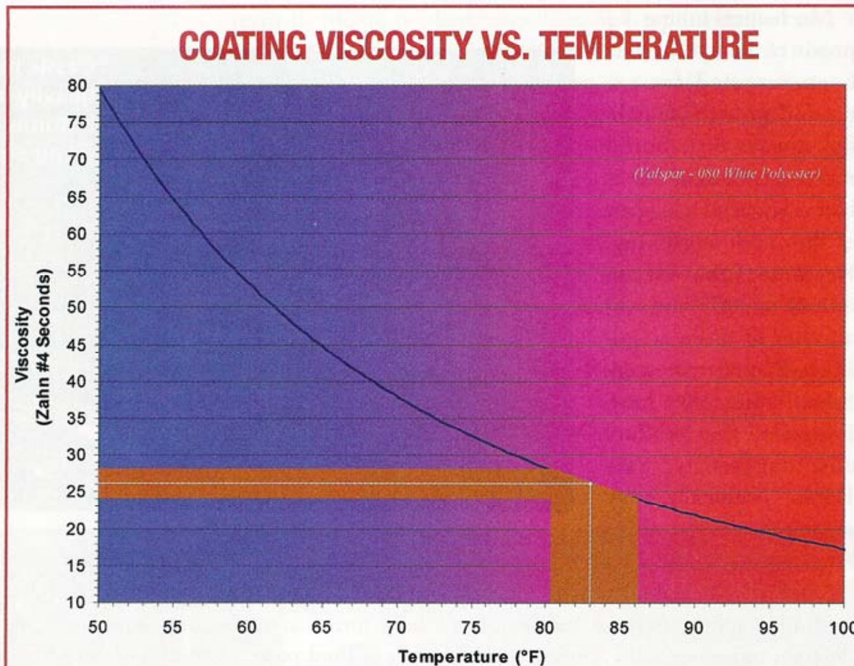
Quality improves and savings accrue when coating materials are held to strict temperature levels

BY MICHAEL R. BONNER

It might be harder than ever to generate profits with coil coating operations.

While corporations demand higher margins to improve shareholder value, global competition allows customers to demand lower prices and longer product warranties. Now, many building products are supported by warranties in excess of 10 years, and roofing products' warranties are out to 30 years or more. Even car bodies nearly all come with a minimum 10-year rust-through warranty.

Lower prices and higher margins leave less money to put into the coating process. Should this downward pressure on processing costs result in manufacturing defects, these defects can result in catastrophic losses before the end of the product warranty cycle. To help avoid these kinds of quality issues, temperature control may offer one of the best tools yet to maintain quality.



Plotted here is the relationship between the coating viscosity and temperature for the Valspar 080 white polyester used at Alsco Metal Products. The entire acceptable viscosity range (26 seconds, ±2 seconds) relates to a 5-degree-F window from 81 degrees F to 86 degrees F. When the temperature is above 86 degrees F, the viscosity will be too low, making it difficult to establish proper film builds. When the temperature is below 81 degrees F the viscosity will be too high and can be reduced with thinner—a common practice.

Temperature impacts quality

Almost all coaters understand the problems that temperature variations cause in the coating process. Significant quality issues with film build, color match, surface finish and other parameters can all be traced to temperature-related viscosity variations. The magnitude of these issues causes many coaters to attempt to control the process by adjusting coating material viscosity.

The reasons for this approach are straightforward. All liquids show some change in viscosity as a function of temperature; generally as temperature increases, viscosity decreases. This change is usually most pronounced in the normal ambient range. Even water goes through a viscosity change of nearly 2:1 between 50 degrees F and 100 degrees F.

Coating materials are no different. Note that this characteristic is a physical material property, not a defect. As such, this parameter can be exploited to improve process performance. For the purposes of this discussion, we focused on a Valspar 080 white polyester coating commonly used at the Alsco Metal Products facility in Roxboro, N.C. This

A SOURCE FOR TEMPERATURE CONTROL

St Clair Systems Inc. offers temperature control systems for coil coating operations. Such controls are critical because the viscosity of all coating materials is directly affected by temperature. Still, most operations don't have reliable systems for accurately measuring coating material temperature nor are they able to control temperature adequately to ensure consistent application of coating materials.

As part of setup, solvents are often added to the coating material to achieve the proper viscosity for application. But ambient temperature and other process variables change the material temperature during the run and can make an otherwise good batch of material fall out of specification as it is being processed.

Additionally, temperature-based viscosity variations across a web or strip result in film build discrepancies from edge to edge. Often attempts are made to compensate for such discrepancies by adding more material to assure that all areas are above the minimum specification.

St. Clair Systems has developed methods to monitor and accurately control coating material temperature in coil coating processes. These controls work to assure repeatable material viscosity and allow other process variables, such as pressures and roll speeds, to become repeatable as well. When temperature problems are eliminated, savings are possible in setup time, waste, material consumption and solvent usage. All of these savings can significantly improve profitability.

material was selected as it is a typical coating material, and Alsco had a significant volume of production data available for analysis.

For Alsco's process, the optimum viscosity for the 080 material (measured with a Zahn No. 4 cup) is 26 seconds, ±2 seconds. If we superimpose this on a temperature-viscosity graph for the material it becomes clear that the entire acceptable viscosity range relates to the 5 degrees F window from 81 degrees F to 86 degrees F. (See "Coating Viscosity vs. Temperature," page 34.)

If the material temperature is outside of this narrow window, the viscosity will be outside of its optimal range and it either must be corrected or other process parameters must be adjusted to compensate. For instance, when the temperature is above 86 degrees F, viscosity will be too low, making it difficult to establish proper film builds and color match. When the temperature is below 81 degrees F, the viscosity will be too high, requiring increased roller pressures to maintain proper film builds and making it difficult to achieve the desired surface finish.

From this it is clear that viscosity has a significant impact on process quality and temperature has a significant impact on viscosity. It follows then, that any changes in material temperature will impact process quality.

Coaters turn to solvents

Few corrections are possible when the temperature is above the 86 degrees F upper limit and the resulting viscosity is below the 24 second lower limit. In a system without temperature conditioning other actions, such as adjusting roller pressures and speeds, need to be undertaken. Likewise, when the temperature is below the 81 degrees F lower limit, the resulting viscosity is above the 28 second upper limit. The most common practice in such instances is to add solvent to reduce coating material viscosity. Because the addition of solvent represents a simple volumetric ratio, the relationship between solvent addition and change in viscosity is linear.

Alsco's production data reflected 394 runs using the Valspar 080 white material over a 19-month period. It encompassed all shifts and all operators. Analysis of that data revealed that, despite the North Carolina location and its relatively moderate year-round climate, the 080 paint was brought to the process in the desired 81 degrees F to 86 degrees F temperature range only 13 percent of the time. More than 63 percent of the time it was below that range. In fact, more than half of these batches (54 percent) fell into the 60 degrees F to 75 degrees F range.

These cold batches (in the 60 degrees F to 70 degrees F range) required a viscosity adjustment on the order of 15 seconds. A reduction of this magnitude required the addition of nearly 5 percent solvent by volume. This amounts to approximately 2.5 gallons per 50-gallon drum. Note that every ounce of this solvent will be driven off in the oven as the paint is cured, to be either incinerated or, worst case, discharged to the atmosphere. (See "Ways to Modify Viscosity," page 36.)

The relationship between temperature and viscosity demonstrates that temperature impacts viscosity in a manner similar to solvent addition. A change in temperature from 60 degrees F to 70 degrees F produces a 15 second change in viscosity, the same as the addition of 2.5 gallons of solvent.

How to reduce solvent use

The use of temperature for viscosity adjustment significantly reduces solvent usage. The magnitude of this reduction can be easily calculated if a few basic operating parameters are established. Continuing with the Alsco example, we will utilize the following conservative assumptions:

- 2.5 gallons of solvent per drum
- 14 drums of paint per day
- 54 percent of drums subject to these parameters

• Xylene specific gravity equals 0.86

Using these parameters we can calculate solvent usage reductions to be realized through the elimination of solvent addition for viscosity adjustment:

• 2.5 gal. x 14 drums x 365 days x 54 % = 6,899 gal./year

• 6,899 gal. x 8.34 lbs./gal. x 0.86 = 49,478 lbs./2,000 = 24.75 tons

In this instance, solvent usage is reduced by almost 25 tons per year, and oven solvent levels also are reduced. For coating lines that have limited speeds due to oven solvent levels this presents the opportunity to increase line speed and increase throughput. For coating operations whose production is limited by emissions-permitting restrictions, this offers the additional opportunity to increase throughput without increasing permit levels or purchasing emission credits.

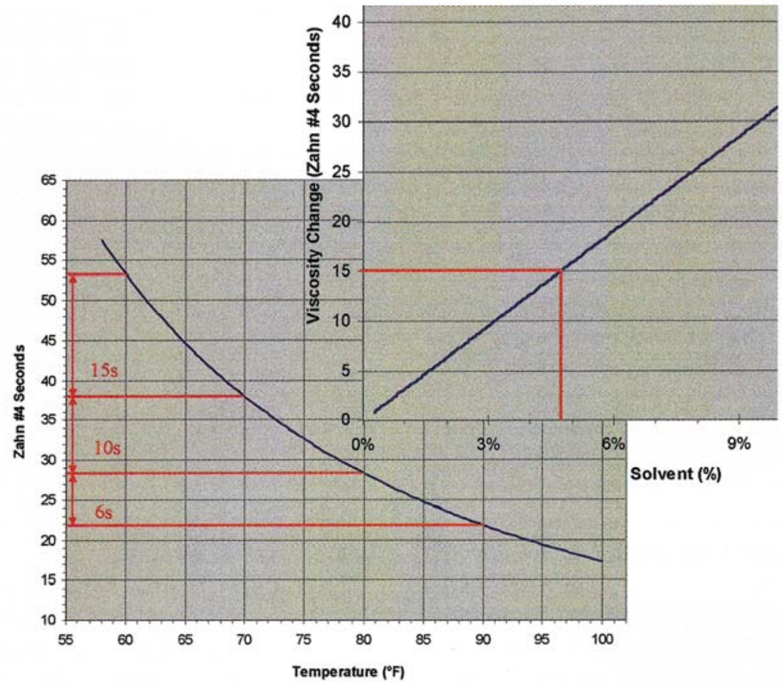
If solvent addition can be eliminated it reduces labor and solvent costs. If Xylene thinner cost $3 per gallon and it takes 10 minutes to measure and adjust viscosity at a burdened labor rate of $35 per hour then savings would be:

• Material savings: 6,899 gal./year x $3/gal. = $20,697/year

• Labor savings: 10 min. x 14 drums x 365 days x 54% = $16,100/year

In this case, the conversion from solvent-based viscosity reduction to temperature-based viscosity control not only offers significant operational improvements but also offers cost reductions on the order of $36,797 ($20,697 + $16,100).

WAYS TO MODIFY VISCOSITY



Temperature variation and solvent addition both impact viscosity in a similar manner. As can be seen, an increase in temperature from 60 degrees F to 70 degrees F produces the same change in viscosity as adding 2.5 gallons of solvent to a 50-gallon drum.

What impacts temperature

While coating material viscosity can be adjusted for a specific temperature at a specific point in time using solvent, the mechanics of the coating system will endeavor to change that temperature (and thereby the viscosity) during processing. Many factors combine to determine temperature at any point in time in the coil coating system. These include:

• Coater area ambient temperature
• Material storage temperature
• Volume of material in source container
• Volume of material in coater pan
• Surface area of coater pan
• Material flow rate
• Pump type/horsepower
• Roller drive motor horsepower
• Roller pressure settings
• Temperature of strip presented to coater

Some actions, such as pumping material from the drum to the pan, warming of the strip during pretreatment and friction from the rollers, will always add energy to the coating material and increase its temperature. Others, such as the impact of ambient temperature on exposed coating material surfaces, will either add or remove energy, depending on the circumstances. It's not uncommon for ambient influences to remove energy from the coating material during the cooler morning hours and then add energy as the afternoon becomes warmer.

This is simple physics, and there are no exceptions. The varying nature of these factors means that operators must continuously monitor the process and attempt to correct for temperature-based viscosity changes that occur in the coating material. This has led many in the industry to refer to the coil coating process as more art than science. (See "Effects of Process Components on Temperature," page 38.)

On almost all coil coating lines, these factors will result in a net increase in the energy added to the coating material. This suggests that controlling ambient temperature alone isn't sufficient to maintain the temperature of the material being processed. This is confirmed by placing temperature probes at several points in the process, along with one probe that monitors air temperature in the coating area. With this arrangement it can be shown that the typical coil coating process can increase as much as 10 degrees F over an hour's time, while ambient temperature increases only 5 degrees F over this same time.

If a probe is placed in the drum during this experiment, it can be shown that drum temperature varies widely as the emptying drum is refilled from bulk supply. It may come as some surprise, however, to find that this has little or no effect on the temperature of the material at the face of the pickup roller. Other factors influencing process temperature combine to completely swamp its effect. This seems to dispel the prevailing myth that drum temperature is the dominant factor determining process temperature. In fact, this suggests that drum temperature is only important when making viscosity measurements and solvent additions.

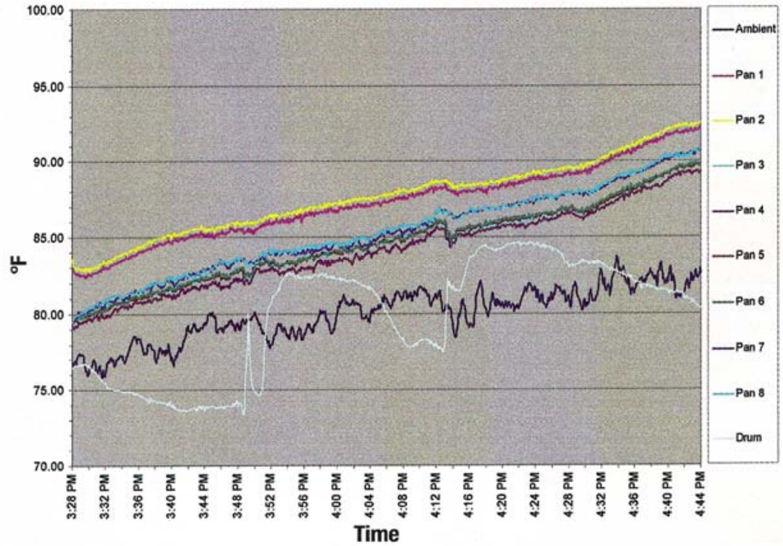
Know the primary goal

It seems clear that the goal must be to reduce viscosity variations as the coating material is being applied to the strip. This suggests that the most important point in the system is the ½-inch thick area in the pan directly adjacent to the face of the pickup roller. This is where the coating material being applied actually originates.

Flow dynamics have a strong impact on this area. Swirls and eddy currents in the pan cause temperature differentials to build up across the face of the pickup roller. If temperature probes are placed in this area it can be shown that variations across the face of the pickup roller can exceed 7 degrees F across a 24-inch strip. Wider strips can deviate even further. These temperature differences amount to viscosity variations. The result is that portions of the coating across the width of the strip will always be outside of the viscosity specification. (See "Thermal Profile Variation.")

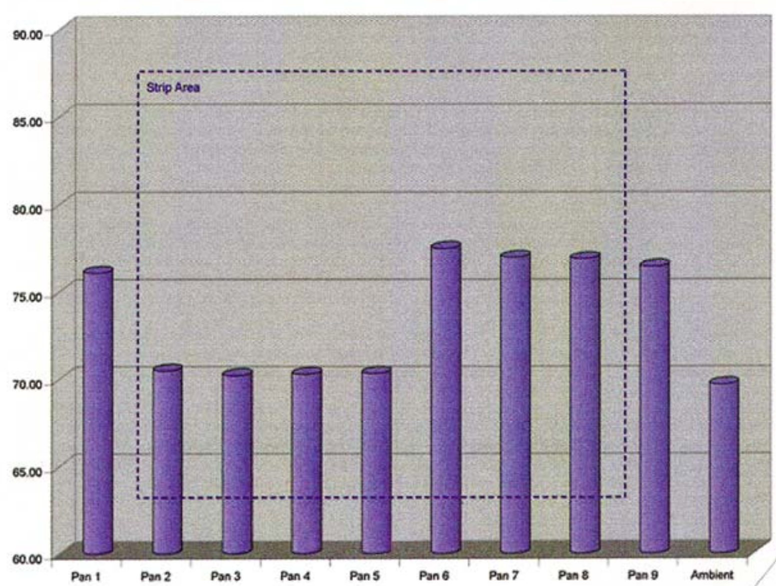
These viscosity deviations are often sharp changes that can't be compensated for by simply varying applicator roller pressure from side to side. To ensure adequate film build at all points across the width of the strip, it's often necessary to increase the total film build. More material is laid down in some areas to ensure minimum coverage in others. Identifying and correcting the factors that create viscosity variation at the point of use can be complex and must be treated on a case-by-case basis. It seems clear from our work at Alsco Metal Products,

EFFECT OF PROCESS COMPONENTS ON TEMPERATURE



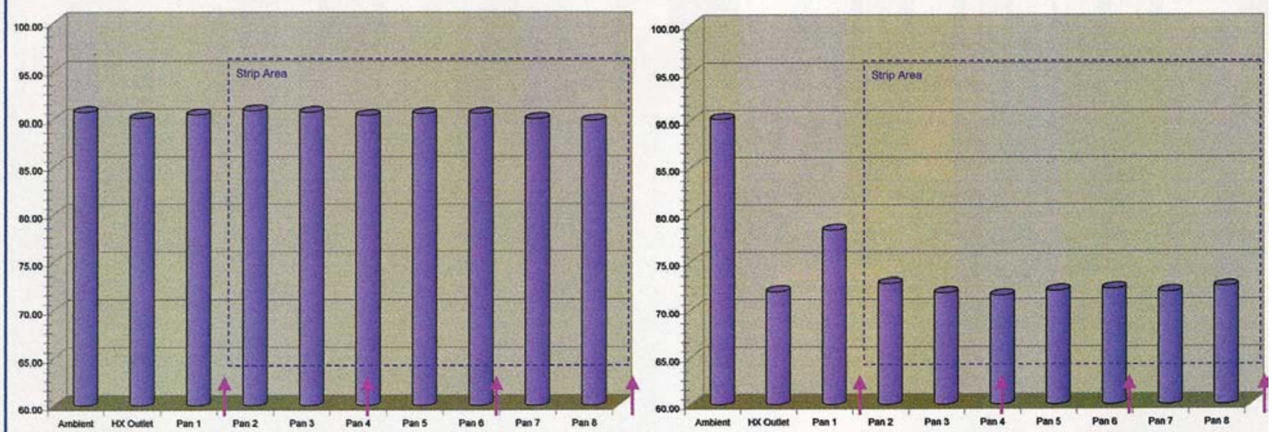
While coating material viscosity can be adjusted for specific temperatures at specific points in time using solvent, the mechanics of the coating system will endeavor to change that temperature (and thereby the viscosity) during processing. This graph shows a line with no temperature control installed on which ambient temperature, drum temperature and the temperature at several points across the face of the pickup roller were recorded over an hour's time. Note that process temperature rises 10 degrees F while ambient temperature rises just 5 degrees F.

THERMAL PROFILE VARIATION



Various points across the face of the pickup roller show significant variation in temperature. Even on a small 24-inch line, this variation can exceed 7 degrees F. This means that the total temperature tolerance is exceeded by variations across the width of the strip, and portions of the coating across the width will always be outside of the allowable viscosity tolerance.

CORRECTED THERMAL PROFILE



After correction of the thermal profile, the temperature variation across the width of the strip has been reduced to about 1 degree F. This translates to a total edge-to-edge viscosity variation of about 0.8 seconds or just 20 percent of the total operating window. This stability is maintained whether operating near ambient or 20 degrees F away from it.

however, that reducing viscosity variation can only be accomplished through the careful manipulation of temperature. By installing a carefully designed temperature control system and addressing flow dynamic issues, it's possible to improve the thermal profile significantly. By implementing these together it's not uncommon to reduce temperature variation across the width of the strip to a total of 1 degree F. This translates to an edge-to-edge viscosity variation of about 0.8 seconds or just 20 percent of the total operating window. Furthermore, this stability is maintained whether operating near ambient temperature or 20 degrees F from it. This is important because ambient temperature variations in excess of 20 degrees F over the course of a day are not uncommon in many coating facilities, as morning temperatures in the 60s become afternoon temperatures in the 90s. (See "Corrected Thermal Profile.")

Ways to save

This stability presents yet another opportunity for significant cost savings through the reduction of coating material usage, which is generally one of the greatest costs in coil coating operations. Where a 1-mil film build is applied to assure that the thinnest areas remain above a 0.8 mil minimum, this flattening of the thermal profile and its associated stabilization of viscosity may allow an aggregate reduction to 0.9 mils or a 10 percent savings in coating material.

In addition to raw material savings,

these process improvements also will result in fewer quality control holds and a reduction of the costs associated with handling, rework, scrap and inventory carrying. The inherent stability of such a system not only eliminates the need for operators to make mid-run adjustments but also can reduce variation in line setup parameters.

By separating coating material temperature from ambient temperature and other influences, line setups become repeatable whether the process is being set up in January or July. This significantly reduces scrap at startup. In all, scrap reductions in excess of 25 percent can be realized. A coating line that consumes $5 million in paint each year and incurs scrap costs of $500,000 can reduce material and scrap costs by as much as: 10% x $5 million/year = $500,000 and 25% x $500,000/year = $125,000, with potential savings of $500,000 + $125,000 = $625,000.

The importance of controlling temperature can't be overstated. A carefully designed and implemented temperature control system can result in repeatable line setup parameters, consistent film build across the strip, consistent film build between runs, reduced coating material usage, reduced solvent usage, reduced emissions, reduced scrap and increased throughput.

With these kinds of results, it's clear that controlling material temperature can have a far-reaching impact on the current and future financial performance of a company. To gain these advantages, temperature must be converted from an uncontrolled variable to a powerful tool that can be used to reduce operating costs and improve product quality. ■

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